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MARKET RISK MANAGEMENT IN BANKS – MODELS FOR ANALYSIS AND ASSESSMENT

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Abstract. *Market risk is connected with the price fluctuations on four of the most important economic markets: market of debt securities sensitive to interest rates changes; stock market; currency market, and commodity market. With regard to this, market risk is the risk that the financial instrument's value will fluctuate as a result from market price changes, regardless of whether these changes are caused by factors typical for individual instruments or their issuer, or by factors pertaining to all the instruments traded on the market.*
This article presents the main components of market risk – interest rate risk, currency risk, and price risk. The methods for interest rate risk measurement include imbalance analysis, duration analysis and simulation model. The Value at Risk (VaR) model is presented as a basic method for market risk analysis. Special place is devoted to stress tests as a technique for reliable risk management used in the potential impact assessment of individual factors or changes in many financial parameters of the bank's income, capital and economic value.

Key Words: *interest rate risk (including revaluation risk, basic risk, option risk), currency risk, price risk, gap analysis, VaR analysis*

INTRODUCTION

Market risk is the risk that the financial instrument's value will fluctuate as a result from market price changes, regardless of whether these changes are caused by factors typical for individual instruments or their issuer (counterparty), or by factors pertaining to all the instruments traded on the market [1]. The four most common factors connected with market risk are interest rates, currency exchange rates, costs of investments in trade portfolio (regardless of the instruments' character – debt or capital), prices of exchange commodities and other market variables related to the bank's activity. The market risk pertaining to both individual financial instruments and portfolio instruments can be a func-

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[1] IFRS 7 "Financial instruments – disclosure"

tion of one, several or all these factors, and in many cases it can be very complicated. In general, market risk can be defined as a risk arising from market movements – of prices, interest rates and currency exchange rates.

The policy for market risk control and management should be subordinated to several main aims:

- to protect the bank against unexpected losses and to contribute to income stability via independent identification, assessment and understanding of business market risks;
- to contribute to bringing the bank's organizational structure and management process in line with the best international practices and to set minimum standards for market risks control;
- to create transparent, objective and consistent information system of the market risks as a base for reasonable decision-making;
- to establish a structure that will help the bank to realize the connection between the business strategy and the operations on one hand, and between the purposes of risk control and monitoring, on the other.

The admissible threshold of market risk is the amount of potential unexpected loss which the bank is willing to assume because of unexpected and unfavorable changes in the market variables. The admissible threshold of market risk should not exceed the losses which the bank can assume without disturbing its financial stability. The bank's ability to overcome losses caused by market risk depends on its capital and reserves, on the potential losses originating from other non-market risks and on the regulatory capital required for maintaining the business activity.

Risk monitoring is the fundament for effective management process. That is the reason why the banking institutions should have adequate internal reporting systems reflecting their exposure to market risk. Sufficiently detailed regular reports should be submitted to the top management and to the various management levels.

I. TYPES OF MARKET RISK

1. Interest rate risk

Interest rate risk is the probability that variations in the interest rates will have a negative influence on the quality of a given financial instrument or portfolio, as well as on the institution's condition as a whole. Assuming of that risk is a normal aspect of the bank's activity and can be an important source of profit and share value. However, excess interest rate risk can significantly jeopardize the bank's incomes and capital base. Variations in the interest rates influence the bank's incomes and change its net interest revenues and the level of other interest-sensitive earnings and operative costs. Interest rate variations also affect the basic value of the bank's assets, liabilities and off-balance instruments, because the present value of the future cash flows (and in some cases the cash flows themselves) alters when interest rates change. Interest rates variations can also influence the level of credit risk and the ability to retain the attracted resources. That is why the effective interest risk management that keeps risk in reasonable limits is of vital importance for bank stability.

1.1. Sources of interest rate risk

Repricing risk

Banks in their capacity as financial brokers face interest rate risk every day. The most common and debated form of interest rate risk originates from the time differences of maturity (for fixed rate), and changes in the interest rates (for floating rate) of the bank's assets, liabilities and off-balance items[2]. Although these discrepancies are fundamental for the bank's activity, they can expose the bank's income and basic economic value to unexpected fluctuations when interest rates vary. For example, a bank which finances a long-term credit with a fixed interest rate with a short-term deposit can experience a decrease in the future revenues and in its basic value if the interest rates rise. This decrease happens because the cash flows are fixed for the credit period while the interests paid on the funding are variable and the interest rates' increase takes place after the short-term deposit matures (respectively, the interest-related costs increase).

Yield curve risk

The repricing discrepancies can also expose the bank to changes of the yield curve tilt and shape. The yield curve risk arises when unexpected changes of the yield curve have an adverse effect on the bank's returns or basic economic value. The yield curve risk results from a change in the percentage ratios of identical instruments with different maturities. For example, the 30-year government bond' profitability can change by 200 basic points, while the profitability of a 3-year government promissory note can change by only 50 basic points for the same time period (one basic point is defined as one hundredth of a percent, i.e. 100 basic points are equal to 1%). Or, the basic economic value of a long position in 10-year government bonds, which is hedged with a short position in 5-year government promissory notes, can abruptly drop if the yield curve steepens even if the position is hedged against parallel changes of the yield curve.

Basic risk

The basic risk is a result from a weak correlation adjustment of the interest rates which are received and paid on various instruments otherwise having the same repricing characteristics. When the interest rates change, that absence of correlation can cause unexpected alterations in the cash flow and the spread between assets, liabilities and off-balance instruments with similar maturities. For example, three-month interest rates are paid on three-month inter-bank deposits, three-month Euro-dollar deposits and three-month treasury bills. However, these three-month rates do not from ideal ratios among each other and their profitability margins can change over time. As a result, three-month treasury bills financed by three-month Euro-dollar deposits represent an improperly balanced or hedged position which can cost the bank a lot when interest rates change.

Option risk (risk of client's right of choice)

An additional source of interest rate risk with increasing significance is the risk arising from options imbedded in many bank's assets, liabilities and off-balance portfolios. Formally, these options provide their holder with the right, but not the obligation to buy, sell

[2] Principles for the Management and Supervision of Interest Rate Risk, BIS, Basel Committee for Banking Supervision (BCBS), July 2004

or change in a certain way the cash flow of a given instrument or financial contract. Instruments with imbedded options include various types of bonds and promissory notes with call or put option, credits which provide the borrowers with the right to premature repayment, as well as various types of undated deposit instruments which entitle the depositors to withdrawing their money at any time, often without any penalties. This type of risk can have an adverse impact on the profit or economic value of the bank's own capital via a decrease in the assets' profitability, increase in the attracted funds' price or decrease in the expected cash flow's net present value. For example, if a client repays their credit earlier during a period of decreasing interest rates, the bank will not receive the initially expected cash flow. And thus it will have to reinvest the sum at a lower interest rate.

1.2. Effects of interest rate risk

The interest rates variations can have an unfavorable impact on the bank's income and economic value. That creates two separate, but supplementing perspectives for assessing the bank's exposure to interest rate risk.

Yield perspective: It is focused on analyzing the influence of interest rate variations on the accrued and reported income[3]. This is the traditional approach for interest rate risk assessment adopted by many banks. The income variability is an important and central point of the interest rate risk analysis, because decreased incomes or direct losses can suddenly jeopardize the institution's financial stability, eroding its capital adequacy, decreasing the market confidence and reducing its liquidity. In this respect, the income component, which traditionally is subject to greatest attention, is the net interest income (the difference between total interest incomes and total interest expenses). However, as banks constantly expand their activities that generate other non-interest related income and income based on fees and other non-interest related revenues, we should add the non-interest related earnings and expenses to the net interest income. The non-interest related income, originating from many activities such as credit servicing and different programs for assets' securitisation, can be very sensitive to the market interest rates. For example, some banks provide and administer mortgage loans pools against a fee which is based on the managed assets' volume. When the interest rates drop, the servicing bank can observe a decrease in the fee income, because the basic mortgages are liquidated in advance. Additionally, even the traditional sources of non-interest related incomes such as fees for deals processing become more and more sensitive to interest rates.

Economic value perspective: The market interest rates variations also affect the economic value of the bank's incomes, liabilities and off-balance items. A given instrument's economic value is the estimation of the present value of its expected net cash flows discounted in a way that they reflect the market interest rates. Viewed in broader sense, the bank's economic value is the present value of the expected net cash flows defined as the expected cash flows from the assets minus the expected net cash flows from liabilities plus the expected net cash flows from off-balance items. In that sense, the economic value perspective represents the bank's own capital's (net value) sensitivity to interest rates' fluctuations. In view of the fact that economic value perspective examines the possible

[3] Guidelines on Interest Rate in the Banking Book, Committee of European Banking Supervisors (CEBS), October 2006

influence of interest rates' variations on the present value of all future cash flows, it offers a broader view of the potential long-term effect from the interest rate variations rather than the yield perspective.

2. Currency risk

Currency risk is the risk where the fair value or future cash flows of a given financial instrument fluctuate as a result from changes in the currency exchange rates[4]. Currency exchange rates can be subject to big and unexpected changes, and understanding and managing of the risk related to the currency exchange rates' volatility can be very complicated.

Although it is important to acknowledge that currency exchange rates are definitely a market risk factor, the currency instruments' valuation usually requires knowledge about the behaviour of both spot currency exchange rates and interest rates. Each forward premium or value discount of a given foreign currency against the local one is determined to a great extent by the relative interest rates on the two national markets. Like all market risks, the currency risk evolves from both open and improperly balanced or hedged positions. The imperfect correlations between the currencies and the international interest markets put forward concrete challenges to the efficiency of the hedging currency strategies.

3. Price risk – risk when the fair value or future cash flows of capital and debt financial instruments (stocks, bonds, indexes and derivatives connected with them) fluctuate as a result from market prices' changes, no matter whether these changes are caused by factors typical for individual instruments or for their issuer (counterparty), or by factors related to all the instruments traded on the market. The risk connected with *the commodity exchange prices* is the probability of unfavorable changes in the value of commodities traded by the bank. Price risks associated with commodities differ significantly from interest rate and currency risks, and require careful monitoring and management as most of the commodities are traded on markets where the supply concentration can increase the price volatility. What is more, changes in the market liquidity are often accompanied by significant price volatility. That is why the commodities' prices are in broad lines more unstable than those of most financial assets commonly traded. The risk assessment associated with commodities prices should be performed *market by market* and it should include not only analysis of historical price movements, but also assessment of the supply and demand structure on the market, so that the probability for unusually large price movements can be assessed.

II. MEASUREMENT OF PRICE RISKS

There are a number of methods for the measurement of various market risks. They all require adequate information about the current positions, market conditions and instruments' characteristics. No matter which method is used, the range and preciseness of the measurement systems of a given institution should be proportional to scale, complexity and nature of its trade activity and its positions. Proper control should be exercised over

[4] Guidelines on the Application of the Supervisory Review Process under Pillar 2, CEBS, January 2006

all the elements in the process of market risk measurement and monitoring, including collection and delivery of data about positions, market factors, key preconditions, calculation of risk amount and reporting of risk exposures via appropriate chains of rights and responsibility.

IFRS 7 "Financial instruments – disclosure" obliges banks to disclose:

- *sensitivity analysis* for each type of market risk to which the bank is exposed at the date of financial report showing how profit, loss or equity will be affected by the reasonably possible changes in the respective risk variable (prevalent market interest rates, currency exchange rates, prices of equity instruments or commodity prices);
- *methods and assumptions* used when preparing the sensitivity analysis;
- *changes* during the previous period in the used methods and assumptions, as well as the reasons for those changes.

In addition to IAS/IFRS, Basel II[5] requires from the banks, which use the market risk standardized approach, to disclose their capital requirements for position (interest rate and price risks for debt and capital instruments), currency and commodity risks. The banks which apply internal models for their trade portfolio disclose: for each sub-portfolio – the characteristics of the employed models; description of the stress tests; description of the used approach for back-testing and verification of the accuracy and consistency of internal modeling.

1. Methods for interest rate risk measurement

Banks use different methods for the calculation of interest rate risk, but none is appropriate for all banks simultaneously. Regardless of the diversity, all methods require solid accounting information which is the basis for adequate information necessary for monitoring and timely reporting of exposures to interest rate risk.

The three most frequently used methods for interest rate risk measurement are the discrepancy analysis, the simulation method and the duration method. The application of each individual method depends on the bank's size, the complexity of its activity organization and the level of interest rate risk.

1.1. Discrepancy analysis (GAP analysis)

The discrepancy analysis is the most frequently used method for interest rate risk assessment. Discrepancy is the difference between interest sensitive assets and interest sensitive liabilities (including off-balance items) over a particular period of time. The discrepancy analysis includes both assets and liabilities with fixed and with floating interest rate. Under the discrepancy analysis the bank's assets and liabilities are grouped in different time periods depending on their maturity (in case of fixed interest rate) or on the time remaining until the next change of their prices (in case of floating interest rate). The allocation of interest sensitive assets and liabilities to different revaluation periods allows for showing the discrepancy for each of those periods. The time periods vary for each bank; the discrepancy schedule can include the following categories: 1 day, 2 days – 1 month, 1 - 3 months, 3 - 6 months, 6 months - 1 year, 1 – 2 years, 2 – 5 years, and over 5 years.

[5] International Convergence of Capital Measurement and Capital Standards, A Revised Framework, BIS, BCBS, June 2004

A bank has a *positive discrepancy* when the sum of the assets being revaluated over a particular period is bigger than the sum of the liabilities being revaluated for the same period. A bank has a *negative discrepancy* if more liabilities than assets are being revaluated. The discrepancy is a normal phenomenon and it cannot be avoided or fully eliminated.

The discrepancy affects the profit and is equal to the difference between the assets being revaluated (the liabilities) and the off-setting liabilities (assets). If a bank has a negative discrepancy and interest rates rise, the net interest income will decrease as more liabilities than assets will be revaluated at higher interest rates. But, if interest rates drop, the bank's net interest income will improve. On the other hand, if the bank has a positive discrepancy and the interest rates increase, the net interest income will improve as more assets than liabilities will be revaluated at higher interest rates. If the bank has a positive discrepancy and the interest rates drop, revenues will decrease.

The bank's position in relation to interest rates sensitivity can be measured in several ways. One of the used methods is the ratio between the interest sensitive assets and the interest sensitive liabilities. A ratio of interest sensitive assets to interest sensitive liabilities equal to 1 shows a balanced position; a ratio bigger than 1 shows a position sensitive to assets, and a ratio smaller than 1 shows a position sensitive to liabilities. In principal, the discrepancy analysis shows a periodical and cumulative discrepancy. Regardless of that whether at a particular moment the bank has a position sensitive to assets or to liabilities, that position should always be in line with the management's forecasts about the interest rates movements, and should never be speculative. The most frequently used discrepancy coefficient is the following:

$$\frac{\text{Interest sensitive assets - Interest sensitive liabilities Profitable assets}}{\text{Interest sensitive assets Interest sensitive liabilities Profitable assets}} \quad (1)$$

In some cases, the total assets indicator can be used instead of profitable assets, but that can lead to underestimating the interest rate risk.

The discrepancy shows the risk to which interest income is exposed. For that purpose, the discrepancy can be multiplied by the presumptive value of the interest rate change, so we can obtain the estimated value of net interest income changes, which is the result from similar interest rate movements. That result reflects the deviation of the net interest margin. For example, a bank has a positive discrepancy of 15% in the category '1 year'. If the interest rates decrease by 2%, the net interest margin can decrease by 30 basic points (15% × 0.02). This is an indication for a stable accounting balance sheet and immediate and steady changes of the interest rates. The amount of the interest rate movement used in the analysis can be based on a number of factors, incl. historical experience, modeling the potential movements of the future interest rate and the bank's management's judgment.

The maintenance of a balanced position over all time periods in the discrepancy report does not guarantee that the bank is immune to interest rate risk. The interest rates of different instruments do not change at the same time. For example, the revaluation of deposits with a floating interest rate can be made with a certain delay as regards the loans disbursed at a first-class interest rate.

The 'discrepancy analysis' method has several *advantages*: the method is easy to develop and use; the results are clear and easy to analyze; its performance is best in banks with relatively low profile of interest rate risk and no options.

Although the discrepancy analysis is very widely used when assessing the interest rate risk exposure, it has a number of *disadvantages*: (1) – the discrepancy analysis does not register the fluctuations in different positions' characteristics within one time interval. In the particular case, it is accepted that the maturity or the revaluation of all positions within a particular time interval occur simultaneously – a simplification which is likely to have a greater impact on the calculations accuracy, as the degree of generalization in a particular time interval increases; (2) – the discrepancy analysis ignores the differences between the interest rates spreads, which can originate from changes of the market interest rates (basic risk); (3) – it does not register changes in payment dates which can occur as a result from the interest environment changes. For that reason, the discrepancy analysis does not register the differences in the income sensitivity which can result from option-related positions. On account of that, the discrepancy analysis broadly and roughly outlines the actual change of the net interest income which results from the chosen change of interest rate dynamics; (4) – most of the discrepancy analyses cannot encompass the fluctuations of non-interest incomes and expenses that represent a potentially important source of risk for the current income.

1.2. Duration analysis

One of the discrepancy analysis' limitations is its inability to show the portfolio value or its change as a consequence from interest rates' change. For tackling with this problem, another analytical method for measuring risk in portfolios of interest sensitive securities has been developed.

The duration is a measure for the percentage deviation of the economic value of an individual position which will occur at a small change of the interest rates. It shows the *time and amount of cash flows* which are received before the instrument's contractually-agreed maturity. On principle, the longer the maturity period and the period for the next change in the instrument's price is, or the smaller the payments received prior to maturity are (for example, coupon payments), the longer the duration is. The longer duration means that a certain change in interest rates levels will have a greater impact on the economic value.

The modified duration is a variety of the simple duration which calculates the interest rate risk sensitivity of the instrument's price.

The difference between the simple and modified duration is that the first one is expressed in time units, while the second one is a ratio. In the financial circles the term *duration* usually refers to modified duration.

The duration measures the average life-cycle of an individual interest sensitive instrument. Its characteristics are as follows: it decreases over time; it is always shorter than the instrument's maturity period, for which payments are made prior to the maturity date, and it is always equal to the residual period until the zero-coupon instrument matures.

The following examples are an illustration of how duration is calculated:

A bank buys a 3-year bond at nominal value of BGN 1,000 which has a 10% annual interest. To calculate the duration we should first calculate the net present value of each payment. This calculation is performed by using the following formula:

$$NPV = \sum_{i=1}^{n} \frac{Values_i}{(1 + rate)^i} \quad (1)$$

where

NPV = net present value
I = year of payment
Value = principal to be paid;
Rate = interest rate

Then the net present value (NPV) of each payment is multiplied by the time of payment (T) and finally they are summed up. That sum, which in our example is equal to 2,735.4, is divided by the instrument's net present value (shown as 1,000), and from which we obtain a duration of 2.74 years.

Modified duration analysis

The modified duration is the calculation of given instrument's price sensitivity (elasticity) to small changes in the market interest rates. Elasticity shows the percentage increase or decrease in the particular factor as a result from changes in another factor. Like all types of elasticity, modified duration can also be calculated by using a mathematical formula.

Using these methods, banks take into consideration the market value of every debt instrument with a fixed interest rate, and then they calculate the instrument's profitability until it matures, which represents the internal discount rate of that instrument. In cases of instruments with a floating interest rate, banks use the market value of every instrument and then they calculate its profitability based on the assumption that principal is due at the next change of the interest rate. Banks calculate the modified duration for each debt instrument using the following formula:

$$D^M = \frac{D}{(1+I)} \quad (3)$$

where:
D^M = modified duration;
D = simple duration;
I = profitability.

The duration analysis as a whole is an excellent conception for the measurement of risks pertaining to a securities portfolio with fixed income. With other portfolios, however, the duration method is inappropriate because it measures only the interest rate risk sensitivity. Along with all these factors for some time now, the bond traders keep a short position over fixed rate periods of 2 years for example, and at the same time they occupy a long position over fixing periods of 10 years (they take the yield curve spreads in an exceptionally big range), thus speculating with the non-similar movements of interest rates over different periods. Since the duration analysis presupposes identical movement of interest rates, in such cases as the above it does not work.

All these factors have created the need for a new risk measurement method. Such a method would be suitable for various portfolio types and at the same time would use simple principles. *Value at Risk* is such a method, namely.

1.3. Analysis of the type 'simulation analysis'

Simulation methods work on the fact that interest rates changes are not static, but dynamic. Simulation includes a process of generating several interest rate scenarios over a time period and discounting of supposed cash flows in each individual interest rate scenario in order to calculate the present value for every scenario. As a result from the simulation, we obtain a range of probable risk exposures which reflect both the current and expected risk. The main advantage of the simulation methods is that they are dynamic and forward-oriented. Banks can change their interest rate scenarios depending on many factors such as pricing and structure of assets and liabilities. The models also take into account the fact that interest rates do not change similarly in the various maturity groups, so risk caused by unparallel changes in the yield curve can be identified through using a simulation method. The accuracy of those models depends on the validity of the used output data. If output data is incorrect, the results cannot accurately reflect the interest rate risk to which the bank is exposed. Another weakness of those models is that they require technical experience for their development and detailed information about maturities and interest rates. Sometimes it is much more practical and cheaper for the bank to buy a particular program product well-known on the market than to develop a certain simulation model. They are not consumer-friendly and may require more personnel than the other systems for interest rate risk measurement.

2. Value at Risk (VaR) as a method for interest rate risk assessment

The Value at Risk model (VAR) is the most common measurement method used by the banks to generalize their market risk exposures. The bank applies the Value at Risk (VAR) models for measuring the trade and the bank portfolios' market risk and for the potential losses assessment via an appropriate analytical method supported by empirical circumstances and documented analysis. This method is applied consistently and with a higher level of conservativeness when the available data is limited. All instruments that are valuated at market prices are exposed to market risk. These financial instruments are reported in the bank's financial condition report at fair value on the basis of market prices quotes, and the effect from changes in the market conditions is recognised as profit or loss in the comprehensive income statement.

The VaR method is defined as the estimated maximum loss amount from a given instrument or portfolio which can be expected over a particular time interval and a specified level of probability. The level of probability at which that value will not be exceeded, should be determined in advance[6], and in practice it is usually set between 95% and 99% (one-sided confidence interval). In theory, the period when the estimated loss cannot be exceeded is the period required for the sale or hedging of the position (the time for the position's closing-up). The shortest period is one day and it is used in banks, while the longest one is usually one year and is used by investment funds. The standard practice has determined this period to be 10 days (a 10-day equivalent period of holding). Changes in the current portfolio's value are calculated on the basis of possible changes in the risk

[6] Fair Value Measurement and Modeling: An Assessment of Challenges and Lessons Learned from the Market Stress, BIS, BCBS, June 2008

parameters during the following working day. These possible changes of risk parameters can be determined by *three methods* – the historical simulation method, the parametric value at risk method and the variance-covariance method.

2.1. Historical simulation

Under this method, forecasts for the influence of market changes can be made. The method includes the use of historical changes in risk factors and parameters observed over a particular period-extract. Usually, for that purpose the banks go one year back, yet some banks use longer periods of 4 or more years. For each day of the previous year, the banks examine the daily movements and compare with the previous day as regards all market determinants. Here are included all the interest rates, currency exchange rates, movements on commodity exchanges and the volatility of all market variables. If a 1-year historical period is used, this process leads to 250 scenarios. One of advantages in the use of historical scenarios is that these scenarios have already taken place. On the other hand, it is unlikely that in future historical events will happen exactly the same way.

Table 1

	2009			
	Average	Maximum	Minimum	As at 31.12.
Value at Risk in trade portfolio – interest rate risk	1316	1785	526	540
Value at Risk in trade portfolio – *price risk*	408	508	2 1 0	405
Value at Risk in bank portfolio – *market risk*	6056	7767	4277	5305
Value at Risk in bank portfolio – *currency risk*	118	362	32	84
Total Value at Risk	7898	10422	5045	6334
	2008			
	Average	Maximum	Minimum	As at 31.12.
Value at Risk in trade portfolio – *interest rate risk*	2595	4264	808	1327
Value at Risk in trade portfolio – *price risk*	842	1514	210	211
Value at Risk in bank portfolio – *market risk*	1567	5240	386	4735
Value at Risk in bank portfolio – *currency risk*	111	275	60	96
Total Value at Risk:	5115	11293	1464	6369

2.2. Parametric Value at Risk

Under the parametric or structural VaR method, a statistical model for price determinants or market variables is used. Here the presumption is that all risk parameters are 'normally distributed', i.e. the average daily change is zero. The standard deviation of these normal distributions is tested against the historical data about each risk parameter. As the relation between the risk parameters and the portfolio value is set to be linear, a different normal distribution of possible changes in the current portfolio is created when applying the normal distribution of risk parameters to valuation models. With the aid of that normal distribution's characteristic it is very easy to calculate the portfolio's Value at Risk. Value at Risk can as well be used for composite portfolios, and for this purpose the variance-covariance method is applied.

2.3. Variance-covariance approach

According to the parametric VaR method, the most important factor for risk determination of a position containing only one product is product volatility as a result from changes in the risk parameters. That volatility can be calculated with the aid of the standard deviation. In the case of a composite portfolio, we should consider the entire portfolio's standard deviation.

The standard deviation of a composite portfolio with two sub-portfolios consists of three elements:

- standard deviation of the first portfolio;
- standard deviation of the second portfolio;
- factor showing a correlation between the two portfolios.

The structural VaR models can be applied for some option portfolios, but as a whole they cannot measure the value at risk for all option positions. As an alternative to the parametric VaR models, scenario analyses can be used: the grid approach and the Monte Carlo simulation.

Grid / coordinate approach

This approach supplements the structural VaR method on the basis of delta equivalence. It consists of two parts: first, the delta-equivalent parametric value at risk; second, a simple scenario approach. First the delta equivalent value at risk is calculated via the parametric VaR on the basis of the delta-equivalent portfolio. That produces a first-tier effect on the portfolio's price movements and therefore is only part of the actual risk. For calculating the effect of the other variables, the portfolio's first-tier price effect calculated in advance, is gradually removed. Several scenarios for simultaneous movement of prices and volatility are applied on that delta-neutral portfolio. The results from both calculations are summed up and in that is how the portfolio's total value at risk is determined.

Monte Carlo simulation

This scenario analysis is developed to overcome the limitations of the Grid analysis. It is complete and incorporates all market variables. Under it very large number of hypothetical scenarios on the basis of the measured movements in the various market variables during the last year. On the basis of a 250-day scenario used for the historical VaR, we create a countless number of possible scenarios. Each historical result for an individual variable is combined with each possible historical results combination for all the other market variables. As scenarios are randomly drawn out of that large number of scenarios created by the model, the analysis is called the Monte Carlo simulation. These randomly selected scenarios are applied to the current portfolio and the value at risk is calculated. Today, this approach is used as a standard for the evaluation of portfolios with option nature.

2.4. Back-testing

As in all models, the validity of the value at risk models should be tested regularly. This kind of testing is performed by both the financial institution's management and the supervisors. The most evident approach is to make a comparison between the model forecasts for the previous period and the actual results. Such a statistical analysis is called 'back-testing'. One of the value at risk concept's advantages is the easy conducting of that testing.

Generally speaking, back-testing consists of determining how often the value at risk has been exceeded over the examined period. If a 97.7% probability has been established, exceeding should not happen in more than 2.28% of the cases, i.e. in 2.28 days within a 100-day period or 4.56 days within a 200-day period. All the additional tests have been developed to assess the extent to which the probability limit can be exceeded with no fatal decrease in the model's reliability.

Although the value at risk is a good instrument for risk measurement in the portfolio under normal circumstances, the model manifests shortcomings in extreme situations known as 'events'. This could be overcome by complimenting the value at risk analysis with a method that provides more information about the risks arising under extreme market circumstances. This additional method is called 'stress testing'.

2.5. Stress tests

Stress tests are a way to identify the risk to which the ban is exposed when the model assumptions cannot be applied or in the case of exceptional events. Stress tests are used to determine whether the financial institution is strong enough to overcome extreme shocks on the financial markets. Stress testing is a set of techniques which measure the influence of exceptional, but not impossible market conditions on the bank's incomes or financial position[7]. Prior to conducting the portfolio stress test, the frame of its performance should be created to include: the possible scenarios, assumptions as regards the market conditions, portfolio revaluation and possible applications of the stress testing results.

In choosing the possible scenario, the market variables which should be stressed are affected. A decision should be taken on whether to stress just one variable over time or a set of several variables simultaneously. The first method relates to *sensitivity analysis*. The second method under which several market variables *'collapse'* simultaneously is called '*a scenario one*' (see Table 2).

After having selected the variables which are to be stressed, the risk manager should add the stress test details, by for example making some assumptions that everything can change under extreme circumstances. For the purpose, suggestions are made in the following areas: degree of shock, volatility, correlation, market liquidity, financial limitations of own bank, market structure, risk inter-relatedness.

The stress test results can be used for different purposes, such as risk reporting, identification of portfolio weaknesses, establishment of risk limits, capital allocation, and positions adjustments.

The main disadvantage of stress tests is that they are too expensive and do not ensure a 100% guarantee against the maximum market risks to which banks are exposed. Despite all that, stress tests remain a mandatory supplement to the standard method 'Value at Risk. Used along, these methods render quite an accurate picture of the risks to which banks are exposed when trading on financial markets.

[7] Technical Aspects of Stress Testing under the Supervisory Review Process, CEBS, December 2006

Table 2

POSITION & SPECIFIC STRESS TEST 31/05/20..									
Risk type	**Position analysis**				**Stress test**				
	Description		**Notional amounts**	**Var**	**Description**	**P&L**	**Equity effect**	**Htm & DSL**	**Total**
FX	Open FX position	FX Treasury Position (excl. EUR) FX Treasury Position against EUR FX Capital Position against EUR	2.5 31.8 275	-	20% depreciation of local currency against all foreign currencies	62	-	-	**62**
		FX Limit (excl. EUR): 2 FX Limit Treasury Position against EUR: 50 long, 10 short FX Limit against EUR: 325 long							
IR	Core banking, interbank transactions & wholesale funding	Retail Deposits Wholesale Deposits Wholesale Funding Loans Interbank Placements	1,377 623 403 1,980 344	-	+200 bps shift in swap curve (BGN only) +100 bps shift in swap curve (all other currencies)	-	-	5	**5**
		IR Bank Limits: 1Y eq.: 350 & 10Y eq.: 125 Assets: 2,869							
IR	Bonds & asset swaps	Government Bonds - Asset Swaps Government Bonds Corporate Bonds	147 13 49	-	+200 bps shift in swap curve (BGN only) +100 bps shift in swap curve (all other currencies) +100 bps increase in Country's credit spread	0	-8	0	**-8**
		Total Bonds Avg Maturity 4.07 Y - Longest 26.2 Y							
IR	Other derivatives	FX Derivatives CCIRS IRS	267 380 25	-	+200 bps shift in swap curve (BGN only) +100 bps shift in swap curve (all other currencies)	8	-	-	**8**
EQ	Equity portfolio	Proprietary portfolio of BSE-listed shares	1.8	0.18	20% drop in equity prices across the board	-0.11	-0.24	-	**0**
		Equity limit: 2.0							
					Total stress test	**69**	**-8**	**5**	**66**

3. Sensitivity to market risk

The analysis of the assets and liabilities' sensitivity to market risk in the table below shows the degree in which changes in the market interest rates, currency exchange rates, prices of shares or exchange tradable commodities can have an adverse impact on the bank's incomes and capital position (see Table 3).

Table 3

31.12. 20..				
	Total effect on economic value	**Direct effect on income report**	**Direct effect on capital**	**Other**
Interest rates				
+250 b.p. parallel shift for local currency +200 b.p. parallel shift for other currencies	**16,992**	(737)	(2,030)	19,759
-250 b.p. parallel shift for local currency -50 b.p. parallel shift for Euro -25 b.p. parallel shift for other currencies	**(11,622)**	728	546	(12,896)
Stocks / Stock indexes / Mutual funds				
-25% price decrease	**(1,010)**	(318)	(692)	-
+25% price increase	**1,010**	318	692	-
Currency exchange rates				
-25% depreciation for local currency	**19,486**	19,486	-	-
20% appreciation for local currency	**(15,589)**	(15,589)	-	-

CONCLUSION

In contrast to the traditional credit risk, market risk does not arise as a result from the inertness of the issuer or seller of financial instruments or assets. Market risk, as we have defined it, is the risk of possible losses from the bank' balance sheet and off-balance sheet items as a result from adverse dynamics of the market prices. The risk arises not only from market changes, but also as a result from actions performed by market participants which can take risk upon themselves, but can as well 'rid of' it. The increase in the potential market risk for banks is explained with the diversification of the bank's business activities which go beyond the frames of traditional brokerage functions and adopt trading and investment operations with financial instruments that bring high potential income for capital increase, but at the same time make banks face significantly higher risk. Market risk is associated not only with the standard instruments, but also with various derivative financial instruments such as options, forwards, futures, and swaps (derivative instruments of stock capital, currency and interest derivatives).

In its essence, market risk requires adequate management and analysis systems to assess each significant risk element; to use generally accepted financial concepts and techniques for risk measurement; to have accurately documented quantities and parameters. Basel III (the Basel Committee's reforms program) sets new special requirements for the

bank's capital for covering the market risk, which are related to rigorous qualitative and quantitative standards of this risk management process.

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UPRAVLJANJE TRŽIŠNIM RIZICIMA U BANKAMA – MODELI ZA ANALIZU I PROCENU

Emilija Milanova

Tržišni rizik je povezan sa fluktuacijama cena na četiri najvažnija ekonomska tržišta: tržištu dužničkih hartija od vrednosti osetljivih na promenu kamatnih stopa; berzi; deviznom tržištu, i tržištu roba. U vezi sa ovim, tržišni rizik je rizik da će vrednost finansijskog instrumenta fluktuirati kao rezultat promena u tržištu cena, bez obzira na to da li su te promene prouzrokovane faktorima tipičnim za pojedinačne instrumente ili njihove emitente, ili faktorima koji se odnose na sve instrumente kojima se na tržištu trguje.

Ovaj rad predstavlja najvažnije komponente tržišnog rizika – rizik kamatne stope, devizni rizik, i ritik cene. Metodi za merenje rizika kamatne stope uključuju analizu debalansa, analizu trajanja i simulacioni model. Model Vrednosti pod Rizikom (VpR) je predstavljen kao osnovni metod za analizu tržišnog rizika. Posebno mesto je posvećeno testovima opterećenja kao tehnici za pouzdano upravljanje rizikom koja se koristi u potencijalnoj proceni uticaja pojedinačnih faktora ili promena u mnogim finansijskim parametrima prihoda banke, kapitala i tržišne vrednosti.

Ključne reči: *rizik kamatne stope (uključujući i rizik revaluacije, osnovni rizik, opcioni rizik), devizni rizik, rizik cene, gep analiza, VpR analiza*